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RESEARCH REPORT

AIRCRAFT BATTLE DAMAGE REPARE (ABDR) 2000:
WILL ABDR BECOME THE LOGISTICS CENTER
OF GRAVITY BY THE YEAR 2000?

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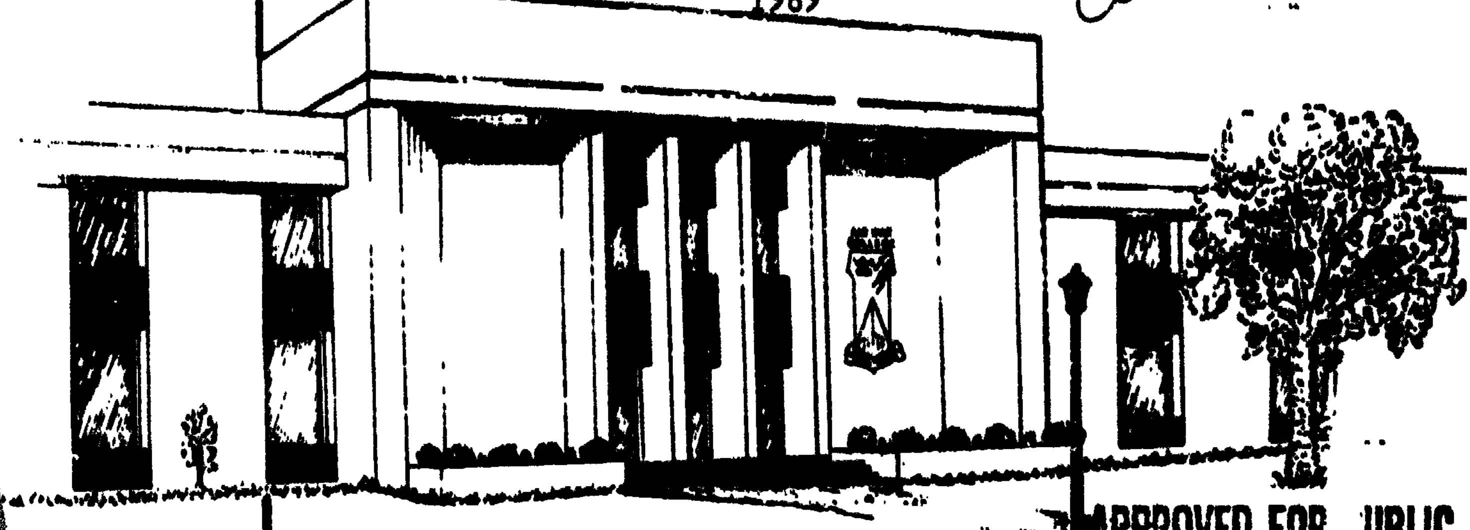
1989



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AIRCRAFT BATTLE DAMAGE REPAIR (ABDR) 2000: WILL ABDR BECOME THE LOGISTICS CENTER OF GRAVITY BY THE YEAR 2000?

by

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A DEFENSE ANALYTICAL STUDY SUBMITTED TO THE FACULTY

IN

FULFILLMENT OF THE CURRICULUM

REQUIREMENT

Advisor: Colonel Michael E. Heenon

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EXECUTIVE SUMMARY

TITLE: Aircraft Battle Damage Repair (ABDR) 2000: Will ABDR Become the Logistics Center of Gravity by the Year 2000?

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Remarks on the impact of advanced technology on weapon system construction and on repair and resupply capabilities in the combat environment. Identifies current trends in weapon systems development and logistics support systems that may converge in the future combat environment with devastating impact on sustainability. These trends include higher reliability weapon systems, reduced logistics infrastructure, reduced field repair capability of composite materials, smaller number of repair parts stocked, and diminished manufacturing sources for micro-technology parts. Concludes that unless increased emphasis and priority are given to the USAF Aircraft Battle Damage Repair program, the air component commander of the 21st Century will have highly reliable combat ready aircraft that cannot be repaired if they sustain significant battle damage. (SDW)

BIOGRAPHICAL SKETCH

Lieutenant Colonel William R. Foster II is a career Air Force Logistician. He has held logistics positions in both retail and wholesale activities at wing, numbered Air Force, major command, and Headquarters USAF levels. In his position at HQ USAF, Colonel Foster was responsible for Air Force acquisition logistics policy and the implementation of new legislation dealing with the application of warranties on new weapon systems. He was also the Air Force project officer responsible for a joint command study on computing combat battle damage spares kits requirements. Colonel Foster is a graduate of the Air War College, class of 1989.

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CHAPTER I

INTRODUCTION

The decade of the 1980's may go down in United States Air Force history as the "Golden Age of Logistics." It might also be referred to as the "Era of Change and Progress." Critical logistics problems evidenced during the 1970s such as parts shortages, unreliable and hard to repair weapon systems, lower quality force, ineffective training, and outdated management procedures and systems were improved during the 1980s. General Hansen, Commander of the Air Force Logistics Command summed it up this way:

> Up until 1981 our funding was very low. For example, the spare parts budget was less than $1 billion at that time. Contrast that with 1985 when it was $5 billion. So we had a tremendous growth in funding. We had good funding in 1983 and 1984, and finally, in 1985, every account in AFLC was funded at 100 percent. That was the premier year for logistics in the Air Force. We'd never seen it before, and we'll never see it again". (1:62)

The 1980s brought in a new Administration, increased logistics funding, and a recognition that the whole spectrum of logistics would have to be improved to support combat requirements through 1980s and 90s. The Air Force leadership began to view logistics as a force multiplier and an essential element of combat capability rather than the dreaded "tail" that restrains operational forces. In 1984, LtGen Marquez, Deputy Chief of Staff, Logistics and Engineering, HQ USAF, commented on the changes:

> We have come a long way since 1981 in correcting many of the serious deficiencies that piled up in the 1970s. The sobering recognition of the essentiality of logistics led directly to a doubling of funding for readiness and sustainability over the past three years. The result is a clear sign that combat readiness is increasing. For example, we are now able to support a more viable training program. Peacetime flying hours are up from 13 hours per aircrew per month in FY78 to about 17 hours in FY82, and now average about 20 per month. ... These kinds of improvements have enabled us to operationally surge to 60% more tactical sorties than we could just three years ago. And, more importantly, we can also maintain our surge rate for twice as long as we could then. ... Much of this improvement is due to the vitality that we restored to spares funding. As a result, mission capable rates for many aircraft are up. More importantly, we are consistently improving our battlefield staying power. (2:9)

During this period, every aspect of logistics was reviewed in terms of its contribution to combat capability. New "combat oriented maintenance and supply" organizations were implemented, maintenance specialities and skills were reorganized to improve effectiveness and flexibility of the maintenance force, aggressive training programs were implemented, battle damage repair teams were organized, and acquisition procedures were improved to buy more capable systems at lower costs, depots began conducting surge exercises, etc. Combat readiness and sustainability became the goal of every logistics organization.

By the mid-1980s, the Air Force leadership recognized that although the logistics problems of the 1970s were being fixed, a more serious problem loomed just ahead. Specifically, the manpower and mobilization demands for

existing and planned weapon systems were overwhelming in terms of cost and airlift requirements. (3:3) In addition, the survivability of logistics facilities, equipment, parts, and personnel in a high intensity conflict was questionable at best. (3:3) The huge logistics infrastructure had to be reduced and streamlined to be more mobile, more combat capable, and survivable. (3:2) Technology, once the nemesis of logisticians due to its complexity and demands for more support equipment and parts, provided a solution.

On 17 September 1984, the Chief of Staff and the Secretary of the Air Force implemented the Reliability and Maintainability 2000 (R&M 2000) program. (4:11) The purpose of this program was to institutionalize the Air Force's new commitment to improving reliability and maintainability of weapon systems. (3:1) The goals of R&M 2000 were to increase survivability of the combat support structure, to decrease mobility requirements per unit, to decrease manpower requirements per unit of output, and to decrease costs. (4:11) The premise behind this initiative was simple. Weapon systems that do not break require fewer parts, support equipment, and people to maintain them. Hence a smaller, more mobile support structure at a significantly reduced cost. Advanced technology was also to be used to improve weapon system self-test and fault isolation in an effort to further improve quick repair

without extensive support equipment and facilities. The R&M 2000 program and related technology efforts received unprecedented Air Force support. Improvements to existing front line systems as well as the Advanced Tactical Fighter (ATF) design requirements incorporated R&M 2000 goals.

The outlook for the 1990s is for more reliable weapon systems and a much leaner logistics support structure. Some Air Force research and development personnel believe that weapon systems will become so reliable that they could operate for 45 days or so with no one having to do more than pump gas and replace expendables. (5:62) Supporting manpower, equipment, and personnel requirements at the flightline level will be significantly reduced.

Does the future really look this rosy? Unfortunately, not. Weapon system reliability improvements coupled with significant changes in other areas of technology spell more challenges for the logistician in the combat environment of the next century. The most serious of these will be the ability of logistician to quickly repair battle damage on advanced technology aircraft. Serious questions need to be answered. For example, if we significantly reduce our maintenance capability and eliminate large portions of the old logistics infrastructure, including spare parts, who will be available

and trained to quickly repair battle damaged aircraft? Where will the logistician get the spare parts needed for this type of repair? Will they be available at base supply, depot, or from industry? Will the base maintenance technician be capable of repairing the high technology composite materials and stealth coatings of the next generation weapons systems?

This report examines these issues in an effort to determine whether aircraft battle damage repair (ABDR) will become the "logistics center of gravity" by the year 2000. To do this, this report reviews the requirement for battle damage repair in the combat environment from both a historical and a future perspective; reviews the current USAF ABDR program, it's progress and problems; identifies the positive impact of high technology on new weapon systems and the logistic support structure; and finally identifies the negative impact of these same changes on ABDR capabilities and requirements for the year 2000.

CHAPTER 2

THE REQUIREMENT FOR AIRCRAFT BATTLE DAMAGE REPAIR

The ability to quickly repair battle damaged aircraft under hostile conditions will be critical for survival of U.S. forces in a future conflict. Peacetime maintenance procedures will not necessarily apply and the speed and difficulty of repair will require extraordinary expertise and innovation. The key question that will be asked is: "Will the repair or patch allow sufficient safety margin so that one more mission can be flown?" This chapter examines the requirement for ABDR in the historical context and defines the critical elements of that experience which are pertinent to the future ABDR scenario.

Historical Experience:

Much of the current historical data available on battle damage repair comes from the conflict in Southeast Asia (SEA) and data available from the Arab-Israeli 1973 Yom Kippur war. Battle damage experience data is valuable for analysis for three reasons. First, the technical performance of U.S. aircraft and enemy threat systems were sufficiently sophisticated to allow extrapolation to systems of the 1990s and early 2000s. Second, good records were gathered on aircraft battle damage and the repairs required

to restore aircraft to service. Finally, the actual data provides insight to the requirement for ABDR in the combat environment and its special problems.

Air Force Systems Command has indicated that SEA combat experience shows, for example, that of the total aircraft assigned, 21% were undamaged, 23% were lost, and 56% sustained some form of combat damage. (6:8) The Pacific Air Forces (PACAF) collected data that shows that in Southeast Asia (April 1972-March 1973), for every F-4 aircraft lost, four returned with battle damage; in a 12 month period of air-to-ground missions, 135 F-4 aircraft were damaged. This was the equivalent of six squadrons out of the fight. (7:91) PACAF also indicated that during the Yom Kippur war for every two F-4s lost, nine were damaged, and in the first week 100 separate cases of major battle damage occurred. This damage was equivalent to five squadrons of aircraft out of the fight. (7:91)

Table 1 provides a summary of selected data collected in Southeast Asia during the period of July 1969 through September 1971 and, briefly, in December 1972. (8:9-149) This data, which is documented in a survey of actual combat experience, reflects the manpower intensive nature of repairing battle damaged aircraft but it also shows that off-line time due to unavailable parts can far exceed the actual repair time. The survey report identifies

two clear messages from the examples contained in the report:

> First, the time required to restore a damaged aircraft to full mission capability is dependent upon having skilled maintenance personnel available and ready to tackle the repair job immediately upon return of the damaged aircraft to the base. These personnel must be fully prepared to assess the extent of the damage which was incurred and then quickly develop the approach to completing the repair. This leads to the second lesson which can be learned from the repairs illustrated here. The maintenance people expected to repair the damaged aircraft must have available tools needed for the repairs but, even more importantly, the spare parts required must be readily available so that the repair work can progress uninterrupted by delays waiting for parts to arrive. (8:173)

The survey report further advises that:

> In some cases, the aircraft were critically needed and all-out efforts were undertaken to return the aircraft to service. These examples may be representative of what the future repair requirement might be since U.S. aircraft assets typically are outnumbered by the adversary. In other examples, the repairs were suspended while awaiting parts to arrive which were requisitioned through the supply system from the depot. This "luxury" may not be available in the next conflict. (8:8)

TABLE 1

AIRCRAFT BATTLE DAMAGE REPAIR EXPERIENCE - SEA
(SELECTED SAMPLE)

Aircraft Type:	Repair Manhours:	Aircraft Off-Line Time:	Notes:
A-37B	58	28 Hrs	All parts available
A-37B	160	34 Days	Part had to be manufactured by contractor
OV-10A	115	21 Days	Part obtained from depot
C-123K	3,420	90 Days	All parts available or fabricated
AC-130A	1,752	12 Days	All out effort by Rapid Area Maintenance Team
F-4D	353	13.5 Days	Parts required from depot
F-105D	176	91 Hrs	Aircraft recovered from alternate base
B-52D	15,000+	Salvaged	739 damaged areas; no repair done

SOURCE: Survivability/Vulnerability Information Analysis Center Report No. AFWAL-/TR-86-3064, Volume I, August 1986

The data in the above survey and Air Force System Command data also highlight those areas of the aircraft most often subject to battle damage. These areas include the bottom fuselage, wings, horizontal stabilizers, aft fuselage, and engine nozzles. (6:9) As might be expected, the external surfaces and internal structures sustain damage in 90% of all battle damage events. (6:10) In the past, these areas required a smaller number of hours to repair than, for example, flight controls, propulsion, power, fuel, and crew station systems. (6:10) This experience may not hold true where new aircraft are increasingly developed with composite and exotic or stealth materials. This historical data clearly indicates that:

- Battle damage affected a significant portion of the aircraft forces in these conflicts.

- Repair capability was very time consuming and dependent on availability of materials and parts.

- The support environment (SEA) was relatively non-threatened.

Based on this information and other studies, one can begin to project the requirements for ABDR in a future conflict scenario to determine if ABDR will be more or less critical than in past conflicts. The next section looks at the future requirement for ABDR and describes their impact on sortie generation.

Future Perspective:

The requirement for ABDR in a future conflict will be similar to the historical experience with one major exception. The future combat environment may be more hostile and ABDR more critical to survival of friendly forces than ever before. In the central European combat environment for example, one would expect that shortly after the beginning of hostilities there would be few or no sanctuaries, a lack of attrition filler aircraft, destroyed facilities and equipment, lack of spare parts, loss of power sources, and possible chemical threats. The 1985 "Salty Demo" exercise of air base survivability at Spangdahlem Air Base Germany provided a preview of a possible combat environment of a base under attack. "The results were a sobering demonstration of the synergistic chaos that ensues when everything goes wrong at the same time." (9:50) Air Force Magazine reports that:

> Thirty-one percent of the base's personnel were casualties, half of them killed and nearly a third of the wounded unable to return to duty. There was considerable destruction and heavy damage to aircraft, vehicles, buildings, communications, and power systems.
>
> In the simulations, fires burned all over, and unexploded ordnance lay about everywhere. It was difficult to assess the damage accurately. Repair teams were short-handed and in some cases did not have the equipment and supplies they needed. (9:50)

This environment would place extreme pressure on the maintenance organization to quickly complete aircraft

repairs for sortie generation. (6:6) The Air Force Human Resources Laboratory's 1986 "Combat Maintenance Capability Project" provides more useful insights to future combat aircraft maintenance capability and in particular to the future requirement for aircraft battle damage repair. The study identified three basic assumptions:

> First, modern military aircraft have unsurpassed combat capabilities due to their considerable sophistication. Second, their actual combat capabilities are a direct function of the effectiveness of the maintenance that can be provided them. Third, the effectiveness of combat maintenance remains untested for new aircraft and uncertainties exist for combat-tested aircraft due to differences in potential combat environments and the many changes in maintenance policies, practices, training, and skill capabilities. (10:1)

This study developed an operational scenario using an F-16 operational wing (72 aircraft) in the 1988-1990 time frame operating in Central Europe. (10:6) "The objective was to describe realistic environments and quantitative data that would identify sortie generation requirements, maintenance workloads, air base damage, and aircraft combat damage." (10:6) Four options were evaluated based on their impact on sortie generation. These included: (1) No ABDR, (2) Base Repair Only, (3) Depot ABDR team (Combat Logistics Support Squadron) Arrive Day 1, and (4) Depot ABDR Team Arrives Day 12. The study concluded that:

> The options of Base Repair Only and CLSS Arrive Day 12 are essentially equally effective in total sortie production over the 30-day scenario. CLSS Arrive Day 1 is most effective in producing sorties both early in the

conflict and over the 30 Days. However, it may be overly optimistic to assume the CLSS would be in place at the beginning of a conflict. Also, the simulations show that the CLSS had no aircraft to repair during 11 of the 30 days, indicating some excess repair capability. All three ABDR options resulted in about two and one-half times the No ABDR daily sortie production by day 30. This emphasizes the value of ABDR in an extended conflict. (10:31)

The Air Force System Command, in a November 1988 briefing for the Air Staff, projected that given 100 operationally ready aircraft on day one of a Central European conflict, approximately 75% of these can be maintained operationally ready for the first 19 days of a conflict if an effective ABDR capability is in place. It indicates, however, that if the ABDR capability is not available, then one should expect to have no operationally ready aircraft by day eight. (6:7)

Both studies reflect the critical requirement for ABDR in any future conflict to generate additional sorties from available combat aircraft. Both studies assumed a level of ABDR proficiency within the maintenance community and availability of materials and equipment to support battle damage repair activity.

A review of the current USAF ABDR program and its status will provide some insight as to whether such capability may or may not be available in such a future conflict. The next chapter examines the USAF ABDR program, its purpose, organization, and program status.

CHAPTER 3

USAF AIRCRAFT BATTLE DAMAGE REPAIR PROGRAM

Purpose:

The current Air Force aircraft battle damage repair program was formally implemented in the mid-1970s to enhance the ABDR capability which is inherent to all operational units which have an aircraft maintenance capability. (11:1) Air Force regulation 66-8, Aircraft Battle Damage Repair, identifies the program objectives as to:

a. Contribute to wartime sortie production by returning combat damaged aircraft to some degree of mission capability as soon as possible.

b. Develop technical data, procedures, training, and kits of tools and consumable materials for use at unit level.

c. Conduct exercise and evaluation programs.

d. Include ABDR requirements in operations plans.

e. Support research and development efforts for better techniques for current aircraft and to contribute to the design of new aircraft.

f. Collect and maintain data to support the ABDR program. (11:1)

These objectives are reviewed annually during a World-Wide ABDR Conference chaired by Headquarters USAF with representatives from Air Force major commands, other services, and allied countries. (12:1) These conferences provide an exchange of technical information and

interservice cooperation, discuss methods to institutionalize ABDR in the Air Force, clarify policy and answer questions, and develop future strategy for ABDR efforts.

Organization:

The organizational structure of the USAF ABDR program begins with specialized maintenance personnel assigned to the using commands. These personnel receive special ABDR training and selected members are qualified to evaluate the extent of battle damage, estimate repair times, specify the repairs to be accomplished, and estimate the resultant capability of the aircraft. These selected members are call "assessors" and provide leadership and oversight to all ABDR efforts. Supporting the using commands are the Air Force Logistics Command and Air Force Reserve Combat Logistics Support Squadrons (CLSS). One active duty and one reserve CLSS unit are assigned to each of the five Air Logistics Centers and one additional reserve CLSS unit is assigned at Wright-Patterson Air Force Base Ohio. Table 2 shows the composition and location of these units. The CLSS provide mobile ABDR augmentation teams to support operating commands during contingency operations and high intensity conflict. (11:1)

TABLE 2
CLSS ORGANIZATION AND BASING

Location (Aircraft)	Active Unit - Manpower	Reserve Unit - Manpower
Sacramento ALC (F-111, A-10)	2951 CLSS - 296	406 CLSS - 239
Ogden ALC (F-4, F-16)	2952 CLSS - 309	405 CLSS - 370
Oklahoma City ALC (KC-135, A-7, B-52)	2953 CLSS - 167	403 CLSS - 201
San Antonio ALC (C-5, B-52)	2954 CLSS - 190	404 CLSS - 162
Warner Robins ALC (C-130, C-141, F-15)	2955 CLSS - 177	402 CLSS - 358
Wright-Patterson AFB (F-4, C-130)		401 CLSS - 322

SOURCE: ABDR World-Wide Conference Minutes, 8-12 June 1987

Other key organizations that support the ABDR program include a ABDR Program Management Office at Sacramento ALC which provides daily oversight for the management and execution of Air Force ABDR program requirements and training. The Air Force System Command is also heavily involved in supporting the ABDR program through its research laboratories and weapon system program offices. Continuous training and realistic exercises provide the basis for evaluation of ABDR capability and program status.

Program Status:

The ABDR program has made significant progress since its inception in the mid-1970s. As indicated above, organizations were tasked by HQ USAF to establish an effective ABDR capability. By the end of fiscal year 1987, the ABDR Program Office projected that 343 ABDR classes would be completed for 493 assessors and 1140 technicians. During fiscal year 1988, 413 ABDR classes were scheduled to train 723 assessors and 1371 technicians. Training sites have been established at 33 locations in the continental U.S., Alaska, Europe, and the Pacific. One hundred and forty training aircraft were assigned to the ABDR program including F-4, F-105, F-101, C-130, C-140, B-52, T-33, F-111, F-102, and Boeing 707 aircraft. (12:111-115) These training aircraft, located on base weapon ranges, are shot by small and medium caliber weapons or are intentionally

damaged by small explosives to simulate actual battle damage. This exposes the trainees to the problems involved in repairing aircraft that have been damaged by ballistic explosive force. A generic ABDR technical repair manual and weapon system specific manuals for many fighter and attack aircraft were published and being used in the training. In addition, new technical manuals were being developed for current generation fighter aircraft such as the F-15 and F-16. ABDR repair manuals for airlifters, bombers, tankers, and helicopters were either in development or scheduled for development in the next three years. ABDR tool kits including repair materials and special equipment were available in most ABDR activities world-wide. Many units mounted these ABDR kits on mobility trailers for quick reaction movements or deployments. ABDR requirements were being included in operational and contingency exercises and live-fire demonstrations were conducted with ABDR repairs to evaluate ABDR effectiveness and aircraft survivability. In addition, advanced technology research programs were underway to develop a host of support systems and methodologies for ABDR.

This progress was not accomplished without difficulty. Although the 1980s has been described as the "Golden Age of Logistics," the ABDR program struggled in the competition for funding. In the early 19[illegible]s when funds were

used to procure critically needed spare parts and updated weapon system capabilities, not all Air Force organizations were enthusiastic supporters of a program that required massive training, tools, materials, procedures, and equipment to conduct an activity that had little payoff in peacetime.

The results of a joint TAC, USAFE, PACAF, and active and reserve CLSS units ABDR field test conducted in April 1987 demonstrated the difficulty of ABDR and the necessity of formal ABDR training. Teams were divided based on a combination of ABDR training levels of assessors and technicians. Two teams, one with no technician training and one with technician training, could not solve the electrical portion of the problem. Of the six fixes attempted by all teams, four did not pass operational checks. (7:101) During the June 1987 World Wide ABDR Conference, the HQ USAF ABDR Program monitor "... acknowledged the slow development of the ABDR program, but highlighted the significant progress seen in the last few months." (7:4)

By June of 1988, ABDR program was described as "... transitioning from a grass roots movement into an institution. We are gradually beating down and wearing out resistance to ABDR and starting to see the program being pulled along by interested leaders and maintenance technicians. One example of this was timely action by

USAFE, SAC, TAC, and PACAF to have some ABDR research and development funding restored." (12:1)

The 1988 World Wide ABDR Conference identified many significant problems that need to be solved to provide an effective ABDR capability. Two of the most important were the need to design new weapon systems for easier battle damage repair and the need for ABDR evaluation criteria to avoid fielding unsound or ineffective ABDR repairs. The Advanced Development Technology Program Manager described priority needs of this program as:

> ... fast curing, long shelf life sealants, wiring repair, the ABDR assessors aid, and ABDR adhesives. A fifth, though underfunded priority is developing ABDR repairs for composites. Of lower priority are radome, canopy, propulsion, landing gear, and secondary power repair. (12:4)

A more recent briefing on the status of the ABDR program to HQ USAF emphasized these ABDR limitations:

- No quality transparency repair,
- Very limited wiring and electronic assessment and repair,
- No propulsion repair,
- Limited integral fuel tank repair, and
- Very limited composite structure repair. (6:16)

Another important need is the development of an ABDR trainer that would allow users to order technology group modules, allowing them to train on technology used in the aircraft

tney support. (12:9) The problem here is the lack of current technology training aircraft such as the F-15 or F-16. Other problems included low readiness of reserve combat logistics support squadrons due to a lack of funding for participation in operational exercises and a continuing lack of many weapon system specific ABDR technical manuals. The HQ USAF ABDR Program monitor expressed his most serious concern this way: "Perhaps our biggest challenge will be to keep our commitment to a viable ABDR program in view of projected funding cuts."

The Air Force's ability to repair battle damaged aircraft has come a long way since the days of the Vietnam conflict. Many of the lessons from that war provided the basis for establishing the existing USAF ABDR program. Significant progress has been made in the late 1980s, but many problems remain to be solved in the early 1990s. The rapid change in technology and the new materials and coatings of the next generation aircraft will pose serious new challenges to be overcome. The next chapter will examine the positive or "up-side" impact of advanced technology on the aircraft and the support infrastructure of the 1990s as a baseline for looking ahead at the potential problems for ABDR.

CHAPTER IV

THE UP-SIDE OF TECHNOLOGY

Todays technology advances in electronics, materials, and design structures allow significant improvements to new aircraft structures and avionics systems. By the year 2000, Aircraft systems may be highly reliable and the number of spare parts, support equipment, facilities, and personnel required to support aircraft systems may be significantly reduced. BGen Goodell, Special Assistant for Reliability and Maintainability, HQ USAF, stated the Air Force's objective this way: "Irrespective of the complexity of the system, whether it be the Advanced Technology Fighter of the 1990s, the newer generations of F-15s and F-16s, the new C-17 airlifter, the small mobile missile, or any other systems destined for the inventories of the United States Air Force, one requirement will be paramount - that the system be twice as reliable as its predecessor, and that it be twice as easy to return to full mission capability. (3:1)

This chapter will examine each of these issues in the context of their potential impact on the logistics infrastructure of the next century. The first challenge is to understand the degree to which new technologies are changing our new weapon systems in terms of electronics, materials, and design structures.

Impact of Advanced Technology on Weapon Systems Construction:

The Advanced Tactical Fighter (ATF) program program provide good insights to this area. The ATF, which is currently in development, is scheduled for first delivery in 1993 and for operational service by 1995. (13:61) The ATF must be capable of meeting the threats of the combat environment of the late 1990s and early 2000s. (13:61) National Defense Magazine stated the problem this way:

> Militarily, the Air Force faces Soviet forces which are numerically superior and supported by a higher rate of aircraft production. The U.S. technological advantage has been significantly narrowed with the latest generation of Soviet fighters. As the only new U.S. fighter planned over the next decade, the ATF must represent a qualitative leap over current Soviet aircraft and maintain an edge over the next generation. To accomplish this, the ATF program will have to adapt and integrate radically new and expensive technology in all areas: airframe construction, engine, navigation, avionics, self-protection, weapon systems, and reliability/maintainability. (13:61)

What does this mean in terms of airframe construction and materials? First, the airframe will be significantly different from existing mainline fighters. "The ATF airframe, planned with 50 percent composite materials, will be 20 percent lighter than current fighters". (13:62) For stealth, developers are experimenting with low-reflective materials such as carbon-carbon fibers, unconventional geometries, and body

configurations featuring conformal sensor and pods. (13:62) "Integration of weapon pods into the airframe contour would be advantageous in reducing radar reflection and eliminating flight performance penalties of external loads." (13:62)

The ATF will also have a fly-by-wire flight control system to control numerous maneuverable surfaces on the wings, tail, fin, and canards for roll, pitch, and yaw, as well as for directional stability. (13:62) One contractor is currently looking at a "mission adaptive wing" which would "... sense flight parameters and manipulate the contour of the wing itself via internal hydraulic actuators." (13:62) The ATF design will probably incorporate hydraulically actuated weapon racks and airframe-conformal sensors (i.e. "smart skins") which will eliminate external metal antennas, pods and domes in favor of airframe-flush signal processing and other combat sensor equipment. (14:86) There is also the possibility that new composites will enable the wing to serve as a massive fuel cell, or "wet wing" where separate fuel tanks would be eliminated. (14:86)

Advance technology will also significantly affect the electronics and avionics of the ATF. Defense Trends magazine in an interview with the ATF program manager described the design of the new ATF electronics:

> Many of the ATF's electronics systems will share components to cut down on weight and size. While each

sensor will have its own unique antenna (some as small as shotgun shells and others hidden in the skin to cut down on radar reflection and aerodynamic drag), processors and computers will be common.

> Fiber optics instead of wire will connect racks of modules built with advanced technologies like very high-speed integrated circuits to make systems even faster. In addition, electronic systems are configured so that if any subcomponent fails, the information will be rerouted automatically without the pilot knowing any problem occurred. (15:31)

The advanced technology such as previously described provides unprecedented opportunities for higher performance, survivability, and reliability of future weapon systems and for existing system through modification programs. One area being pushed very hard is the use of advanced technology to improve the reliability of new systems such as the ATF and existing systems such as our F-111s, F-15s, and F-16s. The next section will look at the use of advanced technology to improve reliability of our weapon systems and the impact on the logistics infrastructure.

<u>Impact of Advanced Technology on the Logistics Infrastructure:</u>

The push for much higher levels of reliability came about as mentioned in Chapter 1 due to the recognition that the logistics infrastructure had to be reduced. General Hansen, Commander of the Air Force Logistic Command recently described the dilemma this way:

> We need to find better ways to provide a defense that can do the job, but at a price this nation can afford.

> Also, we need to find better ways to get the required combat capability from the available resources, thereby reducing the continually growing force structure and logistics requirements.
>
> There is a practical solution to the problem--and effective way to have the force structure we need to fulfill our military commitments anywhere in the world, and at any time, and to save perhaps billions of dollars in the process. The solution is reliability and maintainability (R&M). (16:5)

General Hansen indicated that an early 1980s AFLC study found that "... parts failures accounted for 75% of support equipment costs in aircraft procurement accounts and at least 20% of the Air Force budget." The study also showed that the impact of improving reliability was significant. "In fact, for a composite of fighter aircraft, doubling the mean time between failure (MTBF) would reduce the spares requirements by some 80%." (16:5)

There are a number of examples that show the accuracy of General Hansen's point. The F/FB-111 Avionics Modernization Program, which is being fielded now, raised the MTBF of the doppler radar set from 49 hours to 750 hours and after 2000 flight hours had experienced no failures. The inertial navigation unit was upgraded from just 19 hours MTBF to 4000 hours. (16:6) In another use of technology, C-141 central data computers were redesigned and reconfigured such that spares were reduced from 872 to only 187. (16:6) New programs such as the ATF have stringent R&M goals to ensure these benefits accrue to the next

generation systems. The ATF engine, for example, will be designed to have half the number of parts, 60 percent less maintenance tools and labor, and a 150 percent increase in component life cycles over current generation engines. (13:62)

These uses of advanced technology has also spurred an effort to eliminate the costly and time-consuming intermediate level of maintenance. This is the level where most of the in-shop testing, check-out, and repair of aircraft avionics modules now takes place. The problem is that current weapon systems such as the F-15 and F-16 must deploy with as many as 6 C-141 loads of support and test equipment, much of which could be eliminated if reliability of the systems were improved and new technology built-in-test (BIT) equipment were part of the weapon system itself. This would also significantly reduce the maintenance manpower requirements significantly. The objective of a two-level maintenance concept is already incorporated in the design requirements for the ATF. (5:56) A recent article in Military forum described this concept:

> Each module has BIT so it will indicate a failure. The faulty module will be pulled at the flight line and plugged into a portable tester to verify that it's bad. If it's bad, it goes back to the depot and a new module is plugged in. All the repair will be done at the flight line. (5:60)

The next step will be to use this technology to retrofit existing weapon system avionics to achieve a two-level

maintenance concept. This concept would allow the vast majority of system faults to be identified and repairs made on the aircraft rather than in a base maintenance shop, and only the more serious problem items would be returned to the depot for repair. This can be done on a phased approach by designing modules that are parallel to the old architecture and also design systems with an ability to grow. (5:62) Major Robert Peterson, deputy for the systems integration branch of the avionics laboratory at Wright-Patterson Air Force Base recently commented in a Military Forum article concerning the two-level maintenance concept that:

> It's our goal, once the concept is up and running, to have an aircraft operate for 45 days or so with no one having to do more than pump gas and replace expendables. But that takes a lot of planning and very careful systems engineering. It's not going to happen overnight. (5:62)

The Air Force R&M 2000 program has stated that improved weapon system reliability and maintainability through advanced technology would significantly increase survivability of the support structure, decrease mobility requirements and decrease manpower requirements. (3:3) Survivability improvements would result from the reduction in the large combat support facilities, especially complex maintenance facilities and spare parts storage facilities. Major George Walrond, an Air Force civil engineer, in his study of the impact of increased aircraft reliability on

maintenance facility design concluded that future aircraft technology such as being incorporated in the ATF would likely result in the elimination of the intermediate level avionics shop and reduce the ATF engine intermediate shop to half the size of the F-15 engine shop. (4:111) Reductions in maintenance and manpower requirements envisioned by the ATF due to improved reliability would significantly reduce the mobility requirements evidenced by the F-15 and F-16. "With fault isolation to the shop replaceable unit (SRU) level, the avionics intermediate shop (AIS) would remain at home for the first 30-days of a war, as in the case of deploying F-16s." (3:3) With the airlift saved per squadron, four squadrons of F-15s could be deployed with the same airlift required to move three squadrons today." (3:3)

How quickly these changes to the logistics support structure will occur as a result of advanced technology gains is unknown. What should be remembered is that the changes have tremendous support from the Air Force leadership, the changes reduce logistics costs in terms of manpower, equipment, and facilities, and the changes can be made with existing technology. These very positive changes resulting from new technology may have a very negative impact on the Air Force ABDR program. The next chapter will look at the negative or "down-side" of advanced technology and the challenges it presents to future ABDR requirements.

CHAPTER 5

THE DOWN-SIDE OF TECHNOLOGY

The positive affects of advanced technology on new weapon system performance and reductions in the logistics support infrastructure may have a very negative or "down-side" impact on the Air Force's ability to repair high technology aircraft in the future combat environment. By the year 2000, the difficulty of ABDR will be significantly increased by the previously mentioned technology advancements in electronics, materials, and design structures. Reductions in the logistics support structure, including manpower, equipment, and personnel may reduce flexibility to complete ABDR requirements. In addition, as aircraft systems become more reliable and the number of reliability related spare parts are reduced, the capability to identify and stock parts for ABDR will become more critical. At the same time, the U.S. industrial base is discontinuing production of many sophisticated electronic parts because of low demand or in response to newer technology competition. This chapter examines each of these issues in the context of their potential impact on future ABDR requirements. It first identifies those assumptions concerning the future which support the negative impact of technology on ABDR capability.

Assumptions:

The first assumption is that the existing threat to conventional forces will continue at close to present levels in the next 10 years. This assumption is based on the belief that as nuclear force reduction agreements are reached between the U.S. and the U.S.S.R. the ability of the NATO conventional forces to off-set the larger forces of the Warsaw Pact will become more critical. Agreements may also be reached in the mid-1990s which reduce conventional forces but these reductions will most likely result in the removal of older less sophisticated weapon systems and related forces.

The second assumption is that the current rapid exploitation of technology will continue despite obvious reductions in defense spending. This assumption is based on the fact that weapon system technology cycle is now advancing in response to or as a result of computer and telecommunications technology advances which are being driven by the commercial sectors of the world economy. Advanced technology provides such leaps in weapon system capabilities that no superpower country can afford to be left vulnerable by not using technology in new and existing weapon systems. In addition, these technologies provide opportunities for real reductions in manpower and logistic support force levels of the past. These force reductions

and the related cost reductions will provide substantial support for their early adoption and field use.

The third assumption is that the management and financial support for the ABDR program will be maintained at its current level. Although the level of support for the current ABDR program has improved in recent years, it is doubtful that substantial increases in ABDR manpower, equipment, training and research and development funding would successfully compete for scarce resources in the immediate future where cost reductions are the immediate priority.

The fourth and final assumption is that regardless of the advances in technology of new aircraft, battle damage will occur in a future conflict in ratios similar to historic experience. This is based on the belief that defensive technologies will be used by opponents to develop missile or other systems capable of damaging, if not destroying, our high technology aircraft. Increasing survivability does not translate to fewer battle damaged aircraft. Historical experience indicates that in SEA for every F-4 lost, four returned with battle damage, and in a 12 month period 135 F-4 aircraft were damaged. (7:91) If, for example, the F-4 had been twice as survivable during this same period, approximately 152 damaged aircraft rather than 135 would have returned to base.

With these assumptions identified, a review of the negative or "down-side" impacts of technology on ABDR begins with an examination of the problem of repairing battle damaged exotic materials and structures of the new generation aircraft.

The Problem of Repairing Advanced Materials:

Repairing damaged skins of current aircraft that are primarily made up of aluminum alloy construction is relatively easy when compared to the repair of exotic composite repairs of advanced aircraft. In the aircraft of the sixties and early seventies the damaged skin area was simply cut out, underlying wiring, structures, cables were replaced from stock, ordered from depot, or locally fabricated. The damaged skin area was then replaced or a patch installed and the aircraft was back on the line. As historical experience shows, the biggest problem was the amount of man-hours this type of repair required or the down time experienced awaiting parts. With the advent of the F-15 and F-16 new composite materials and honey combed structures, the ABDR challenge became greater. How much greater seems to be a matter of some debate.

Live fire testing on an AV-8B, "Harrier" aircraft wing in May 1987, resulted in an 18- to 24-inch pothole in the composite wing from a high-explosive 30mm incendiary round. (17:38) In addition to the concern over the

exterior damage to the wing was the concern over the unexpected internal wing damage. James Kitfield described it this way:

> In the "Harrier" wing test, for example, major structural damage occurred within an internal area as much as 30 percent to 40 percent larger than the actual hole. Delamination and splintering of the composite material also raised questions about the ability to quickly repair the damage, and the effect air flow might have in aggravating it during flight. Potentially lethal toxic fumes emitted from composites when they burn also raised concerns. (17:40)

At the time, aircraft designers argued that the test was inconclusive because the wing had already been stressed to the point of fatigue failure in earlier test and it had been loaded with water to maximize the destructive effect of "hydraulic ram," the back pressure created when a bullet or fragment hits a soft-skinned container full of fuel or liquid. (17:38) Others argue that "Because today's composites are tailored to carry loads in very specific directions, it is generally conceded that they leave little margin for error in absorbing unexpected stress, such as random ballistic impact." (17:40)

Traditionally, these issues have focused more on aircraft survivability and costs than on reparability. Indications are that survivability can be enhanced through even more tougher materials such as thermoplastics or composite hybrids containing layers of super-tough Kevlar and ceramic tile which are more damage resistant. (17:40)

Costs are higher than traditional aluminum alloys due to the need to closely control both temperature and humidity in the painstaking process of forming and curing composites. The F/A-18, for example, has 134 separate composite plies in the wing skin alone. However, the increase in performance, reduction in weight, and improved "survivability" may justify their costs from an operational perspective. (17:41) The ability to repair these exotic materials is a more difficult issue.

James Kitfield in his recent article on composites quotes an industry expert in this area:

> Reparability is one of the biggest disadvantages of composites. It's difficult to assess how much delamination has taken place. Then you have to worry about eliminating the damaged portion and putting the whole thing back together. If the composite part is honeycombed--and many are--assessing the damage is even tougher, and repairing it tougher still. Compared with just patching up a hole in a metal part, where what you see is what you get, that's a definite drawback. (17:41)

Confirming this problem, ABDR managers report that a composite that has been shot by a 23mm round or anything bigger, looks like "Shredded Wheat." Any significant damage may require repair capabilities normally associated with depot level repair. (17:42) In fact, since composites first came into use with the F-14 and F-15 aircraft, repairs have been confined largely to depot and factory level activities. (18:66) "The damaged composite flight surfaces

have been removed from the aircraft, patched and placed into huge autoclaves that subject the patched pieces to pressures of over 100 pounds per square inch (PSI) at temperatures upwards of 350 degrees (F) for at least eight hours." (18:66) Experts in repair of composites believe that eventually the field will be able to make minor damage repairs to composites but right now such repairs are not possible. (18:66) Some experts believe that serious damage to composites may never be repaired outside the depot level maintenance center. (18:66) Field repair of the stealth materials and forms, whether on the F-117 fighter, B-2 bomber, or the ATF is another problem. Whether repairs to these materials and specialized shapes can be accomplished in the field has not been discussed in open literature due to the highly classified nature of these programs. The impact of these technologies on ABDR capability in a future conflict may be critical.

In the European theater, for example, the Air Force is counting on the higher sortie rate and capability of it's front-line fighters to offset the superior numbers of Warsaw Pact aircraft in the crucial first days of any conflict. Deployment of fewer but far more capable aircraft such as the ATF will only increase that dependence. (17:41) If field level ABDR personnel cannot repair the composite materials on these aircraft in a very short period of time,

then U.S. forces will be out of aircraft in just a few days. For example, an ATF-type fighter wing of 72 aircraft, tasked to fly a 3.0 daily sortie rate in a wartime scenario would be capable of generating approximately 216 sorties on day one of the conflict. If four percent of the 72 aircraft sustain composite-type battle damage during each daily sortie, and no repairs can be made (assuming no battle losses), then by day six the wing would have only half their aircraft available. By day 10 the wing would be able to generate only 66 sorties. If battle losses are included in this example, then the number of aircraft available at the end of each day is also reduced.

The USAF ABDR program office has been working these problems as previously mentioned in Chapter 2 and ABDR requirements have been included in the ATF development contract. However, the engineering and maintenance challenges should not be understated and the solutions are dependent on funding to support the necessary research and field repair equipment and materials. Compounding this problem may be the current push to reduce the logistics infrastructure needed to support high technology aircraft.

The Problem of Reduced Logistic Infrastructure:

The advent of microchip technology with vastly expanded computing power and the increases in reliability provide opportunities to reduce the current logistics

infrastructure as outlined in Chapter 4. These changes, however, may compound the problem of ABDR in the future conflict for a number of reasons. First, advanced microchip technology allows designers to incorporate self-test and fault isolation capabilities on the aircraft or aircraft subsystem. The need for existing heavy off-equipment test and fault isolation equipment will be reduced to the point of where the flight line maintenance specialist can identify the bad box, circuit card or part without removal of major subsystems to a back shop automated maintenance tester for check-out. Portable testers connected to the built-in aircraft test system may be the only equipment needed at the forward base. More substantial test capability would be located in the depot level facility.

As indicated previously, this allows a two-level maintenance concept as currently planned for the ATF. With the concurrent increase in system reliability, the number of maintenance personnel required and their level of technical expertise can also be reduced since failures are infrequent and when they occur the box or card is simply removed, replaced, and the failed part sent back to depot for repair. It is questionable whether repair at the field level would even be possible given the sophistication of the equipment involved. This also reduces training requirements and the current heavy mobility requirements for current-type

fighter wings. Normally a two-level maintenance concept would require more spare parts be available for the heavier remove and replace parts demands. However, if parts do not fail, then obviously fewer are needed in the base stocks and the war readiness spares kits (WRSK). In fact the current spare parts requirements determination models used by the Air Force Logistics Command are very sensitive to reliability factors when calculating spares requirements. The potential reductions in the requirements for spare parts are used to justify the modification and removal of unreliable weapon subsystems currently in use today.

The down-side of these improvements may be more pronounced in the area of ABDR capability than any other area. The first question that has to be asked is this. In the intensive combat environment of the future where ATF-like aircraft are damaged by explosive force and require immediate repair, will the integrated built-in test systems coupled with flightline testers be capable of identifying all the battle damage induced failures? If the self-test system is destroyed or inoperable, then will the available maintenance personnel have the necessary skills and other equipment to identify ways of fixing the problem and getting the bird off the ground. If the maintenance personnel can identify the failure, then will the spare parts be available in the forward supply system? What about those sensors that

are incorporated into the conformable composite structure of the airframe? If they are destroyed, will they be available in the base supply system? If the parts are not available in the supply system will the maintenance personnel be capable of cannibalizing the needed parts, structures, coverings from other damaged aircraft? If these maintenance personnel have been "remove and replace" experts prior to the beginning of conflict where will they get the knowledge to patch, dismantle, or "jury-rig" extensive fixes in the combat environment?

The answer must lie in the ABDR personnel training, tools, and materials that exist at the time and place of the future conflict. Previous chapters of this report would indicate that that the maintenance chief would experience severe ABDR constraints in the future conflict. These problems may include the the following:

- A lack of sufficient numbers of people who possess the experience and training to assess battle damage and effect repairs. Active and reserve CLSS teams must deploy from U.S. air bases and integrate with in-place units. There is also a question whether CLSS teams will arrive in time to support early ABDR requirements. (10:25) With expected reductions in base-level maintenance personnel due to improved reliability of weapon systems, one might also question the adequacy of numbers of CLSS personnel available

for ABDR requirements in the future conflict.

- Current ABDR kits contain tools, expendable repair parts, fasteners and some repair materials. The equipment necessary for depot level composite material repair, dismantling of damage aircraft or the local fabrication of parts may not be available.

- Current base supply stocks and war readiness spares kits (WRSK) contain parts selected based on their peacetime failure rate. Wartime flying hours and other logistics factors are then applied to determine the appropriate quantity of each part to be stocked. Projected failures due to battle damage are not included in this calculation. The A-10 is the only aircraft to have an ABDR WRSK that contains a limited number of parts for projected ABDR requirements. (19:1) As mentioned above, future WRSK may be reduced significantly due to the increase in weapon system reliability. Therefore, the needed part may not be available.

This last constraint is the result of another negative impact of technology on ABDR that needs to be examined here. This is the difficult problem of identifying parts for ABDR requirements.

The Problem of Identifying ABDR Spares:

The Air Force Logistics Command and Air Force Systems Command began looking at this issue in November of 1986 at the request of the Air Staff. The problem is that "the current WRSK computation does not consider the spares needed to repair combat battle damage." (19:1) Their study used a geometric aircraft simulation model to predict battle damage based on selected threat systems. A second model was then interfaced with the damage simulation model to project suspected parts requirements. A third model was then used to project resource demands and sortie generation capability as well as provide management tools needed to trade off resources. The F-4E was selected for simulation based on the availability of the most complete real-war data base (USAF and Israeli) that could be used to validate the model output. (19:4) The objective was to develop a generic F-4 WRSK based on both wartime failure projections and combat battle damage failure projections. This kit could then be compared with existing F-4 WRSK and differences examined in terms of range of parts, costs, and sortie generation. The results were interesting to say the least:

> The impact of not including combat battle damage spares in the F-4 WRSK is quite serious. An entire squadron of aircraft could be grounded by day 7 if the WRSK does not include the spares needed to repair combat battle damaged aircraft. We also assessed the current kit assuming battle damage for only the 28 stock numbers

> currently in the F-4 WRSK. The squadron would have all aircraft grounded by day 12 if we ignored the battle damage to the 32 items not in the current kit. Thus battle damage significantly affects a squadron's combat capability.
>
> In our assessment, we assumed the threat and the attrition rate was constant over the 30-day period. That is, we used an average attrition rate even though we know that attrition caused by combat damage WILL vary in actual combat. As a result, the battle damage failure rate is less dynamic than during actual combat. (19:7)

The study report indicated that further validation of the modeling techniques and the data bases were needed before the results could be used for actual computation of battle damage WRSK requirements could be computed. This validation is going on at this time and is scheduled for completion by May 1989. (20:2)

The long term implications of these results on future ABDR capability would indicate that unless ABDR spare parts can be identified and included in WRSK or ABDR kits, the future ABDR maintenance chief might have to look elsewhere for parts. The question then is if this problem is not resolved and the base does not have the part, will it be available from the depot or from U.S. manufacturers and can the maintenance chief afford the attendant time delays? This raises the final impact of advanced technology on ABDR and that is the problem of diminishing manufacturing sources for high technology parts.

The Problem of Diminished Manufacturing Sources:

Six experts from several agencies of the Department of Defense (DoD) in their article, "Out-of-Production Micro-Electronics -- An Achilles Heel of Defense Systems," recently identified the nature of this problem:

> A problem that first came to light in the early seventies, and which has shown alarming growth since, concerns the discontinued production of micro-electronic components required by the DoD to support these systems. This problem may take two forms. One is nonprocurability, whereby DoD inventory management activities are unaware of the problem until after production of a part has ceased. The second involves a contractor's advanced notice of intent to discontinue production, followed by DoD's reaction. (21:69)

There are a number of factors causing this problem. First is the long design-to-production lead-time of defense systems such that just as DoD production begins and peak demand come into being, the commercial industry has already begun to move to a new generation technology. "Thus DoD becomes a major user of the component in question only after it has passed its peak in non-DoD popularity." (21:69) Since commercial requirements for a specific technology comprise a life cycle of only four to seven years versus up to 25 years for a defense system, it is very difficult to keep a manufacturer's production line open for old technology.

This is especially true when the reliability of the existing technology is good and failure rates are small. The problem here is that the DoD does not procure sufficient

quantities of these parts on an annual basis for the manufacturer to economically justify keeping a production line or capability available. Ironically, the Air Force R&M 2000 program and the associated push to significantly improve the reliability of weapon systems exacerbates this problem. Basically, to achieve the large improvement in weapon system and subsystem reliability, a manufacturer must increase the reliability of component parts and microchips to many thousands of hours between failure. Of course if these parts do not fail, the government does not procure many of them and does not include them in WRSK or in depot stocks. As the manufacturer takes the part out of production, the government, if notified of the action, can take action to find other sources, make one last large life cycle buy, or modify the systems that the part is used on within each weapon system. All of these alternatives are time consuming and usually very costly.

Although this problem has not reached crises proportions as of yet, the annual number of diminishing manufacturing sources cases show that it is increasing at an alarming rate. For example, in 1977 the Defense Electronics Services Center reviewed 38 diminishing manufacturing source cases involving 1248 micro-electronic parts projected to go out of production. By 1988, the number had increased to 176 and involved 7,431 parts. (22:) In addition, the

nonavailability problem is not limited to older weapon systems. "Of equal or perhaps greater concern is the phaseout of production lines for components for defense systems just going on-line, or in some cases, still in production." (21:70) The DoD has implemented a number of joint service efforts to coordinate and find solutions to parts problems as they arise. Unfortunately, there appears to be no quick inexpensive solution to the overall problem. Diminishing manufacturing sources experts indicate that downstream "Production phase-outs of older micro-electronics technologies will continue to plague the DoD logistics system, probably at an accelerated pace." (21:72)

The prospect for ABDR in the future combat environment is fairly obvious. Advanced technology piece parts needed for repairs most likely will not be available from the base supply system, from the WRSK or ABDR kit, from the depot, and possibly not from industry. As historical experience indicated in Chapter 2, the luxury of waiting for depots or contractors to manufacture parts may not be available in the future conflict where survival may depend on the ability to quickly turn aircraft and generate sorties.

CHAPTER VI

CONCLUSION

The capability to repair battle damaged aircraft in a high intensity conflict of the next century will be critical to survival of U. S. air forces. In the scenario of the Central European conflict, ABDR may be the "logistics center of gravity" that determines whether smaller U.S. air forces can generate sorties needed to support outnumbered allied forces, protect high priority installations, and eventually achieve air superiority. History has shown that even in less intense conflicts with less sophisticated threats, the then current state-of-the-art aircraft sustained significant battle damage. This same level of damage to a potentially smaller fleet of advanced technology aircraft would be devastating unless an effective ABDR capability exists in place with needed tools, equipment, materials, parts, and trained people to quickly turn damaged aircraft for one more sortie.

In recent years, aircraft battle damage repair (ABDR) requirements have received increased emphasis as a result of more realistic operational exercises which evaluated air base operability and survivability capabilities. Active and reserve mobile CLSS teams are now in place in the continental U.S. to augment the operating commands' base ABDR capability in a contingency or wartime

environment. Base level ABDR capabilities for self sufficiency have improved through ABDR training and the development of ABDR kits. The USAF ABDR program is now in place and many initiatives are underway to address the challenges of repairing damage to advance technology aircraft. Command support for the ABDR program continues to improve although slowly and there is concern that the coming budget reductions will adversely impact the program.

By the year 2000, the ABDR requirements will be compounded by technology advancements in materials and parts reliability and resultant reductions in the support infrastructure. Composites materials will be difficult, if not impossible to repair in the field, and as weapon systems and parts become more reliable, fewer will be procured and stocked in base supply, war readiness spares kits, or at the depot. At the same time, industry may have discontinued production of many critical micro-circuit technology parts due to low government demand or because technology has advanced in response to commercial competition. In addition, critical parts needed to return a battle damaged aircraft to a fully operational condition must be identified and included in WRSK or ABDR kits prior to the reductions envisioned by reliability enthusiast.

If these ABDR requirements are not addressed in the very near future, the air component commander of the 21st

Century will have highly reliable combat ready aircraft that cannot be repaired if they sustain significant battle damage. Current ABDR concepts and capabilities need to receive additional emphasis and priority. The push for giant leaps in technology and reliability must be accompanied by similar leaps in ABDR capability. A comprehensive review of the total effects of technology on the war-fighting capability of the logistics system should be undertaken as soon as possible. The ABDR challenge for the next century aircraft is greater than any previous air power era. Our ability to meet this challenge over the next decade may determine our capability to "fight and win" in the Twenty-First Century.

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GLOSSARY

ABDR	Aircraft Battle Damage Repair
AFLC	Air Force Logistics Command
AFSC	Air Force Systems Command
AIS	Avionics Intermediate Shop
ALC	Air Logistics Center
ATF	Advanced Tactical Fighter
BIT	Built-In-Test
CLSS	Combat Logistics Support Squadron
DoD	Department of Defense
MTBF	Mean Time Between Failure
NATO	North Atlantic Treaty Organization
PACAF	Pacific Air Forces
PSI	Pounds Per Square Inch
R&M	Reliability and Maintainability
SAC	Strategic Air Command
SEA	Southeast Asia
SRU	Shop Replaceable Unit
TAC	Tactical Air Command
USAF	United States Air Force
USAFE	United States Air Forces Europe
WMP	War and Mobilization Plan
WRSK	War Readiness Spares Kit
WUC	Work Unit Code